



CARLO GAVAZZI SPACE SpA

RICH

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1	JULY 2007		First issue

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LIST OF ACRONYMS

AD	Applicable Document
CoG	Centre of Gravity
DoF	Degree of Freedom
FEM	Finite Element Method/Model
IF	InterFace
LC	Load Case
MoS	Margin of Safety
NA	Not Applicable
ND	Not Defined
PSD	Power Spectral Density
RD	Reference Document
RMS	Root Mean Square
SF	Safety Factor (or Factor of Safety)
TBD	To Be Defined
TM	Test Mass
VM	Von Mises

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1. SCOPE

This document describes the analyses, models and methodologies utilized to predict the dynamic behaviour of the U-TOF during the vibration test to be performed in SERMS facility.

The scope of the analyses is to predict the behaviour of the U-TOF during the random vibration test and to assess the similarity of the proposed test configuration with the hard-mounted simulations used to design and verify the U-TOF design, according to the applicable specifications of AD1.

In particular, the similarity shall be verified for:

- Main structure modes (frequency , mode shape and effective mass)

The prediction shall provide:

- Induced PSD spectra on some U-TOF reference points
- Induced force on U-TOF interfaces with test fixtures
- CoG acceleration

2. RELEVANT DOCUMENTS

In this section the applicable and reference documents are listed.

2.1 APPLICABLE DOCUMENTS

[AD 1] JSC-28792 "AMS-02 STRUCTURAL VERIFICATION PLAN" August, 2003 REV.C

2.2 REFERENCE DOCUMENTS

[RD 1] RICSYS-RP-CGS-013 "UPPER TOF STRUCTURAL ANALYSIS REPORT " ISSUE 1 DATE 29/06/04

[RD 2] "PROGETTAZIONE DELL'INTERFACCIA PER I TEST VIBRAZIONALI DEL SISTEMA L-TOF" E-mail from SERMS 31/01/2006 12.10

[RD 3] "RICH-TN-CGS-003" "L-TOF VIBRATION TEST PREDICTION" DATE March 2006

[RD 4] "UTOF - TEST DI VIBRAZIONE PROGETTAZIONE INTERFACCIA DI FISSAGGIO" annex to E-mail from SERMS 11/07/2007 16.46

[RD 5] RICSYS-DC-CGS-001 DOCUMENT CHANGE NOTICE TO RICSYS-RP-CGS-013 ISSUE 1 DATE 08/09/05



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3. U-TOF VIBRATION TEST SETUP GENERAL DESCRIPTION

Two different configuration are foreseen, one for shaker vertical vibration, using a dedicated fixture (named Z-FIXTURE) and one for sliding table using four stand-off fixtures (named XY-FIXTURE):

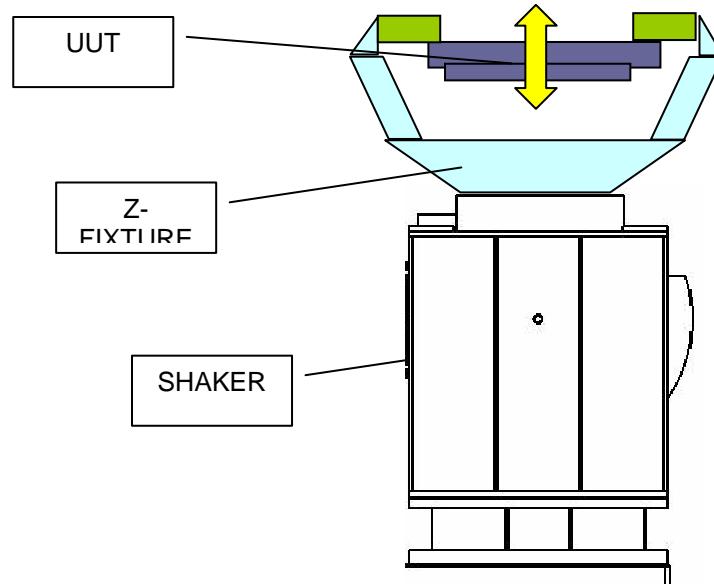


Figure 3-1 U-TOF Z VIBRATION TEST SETUP

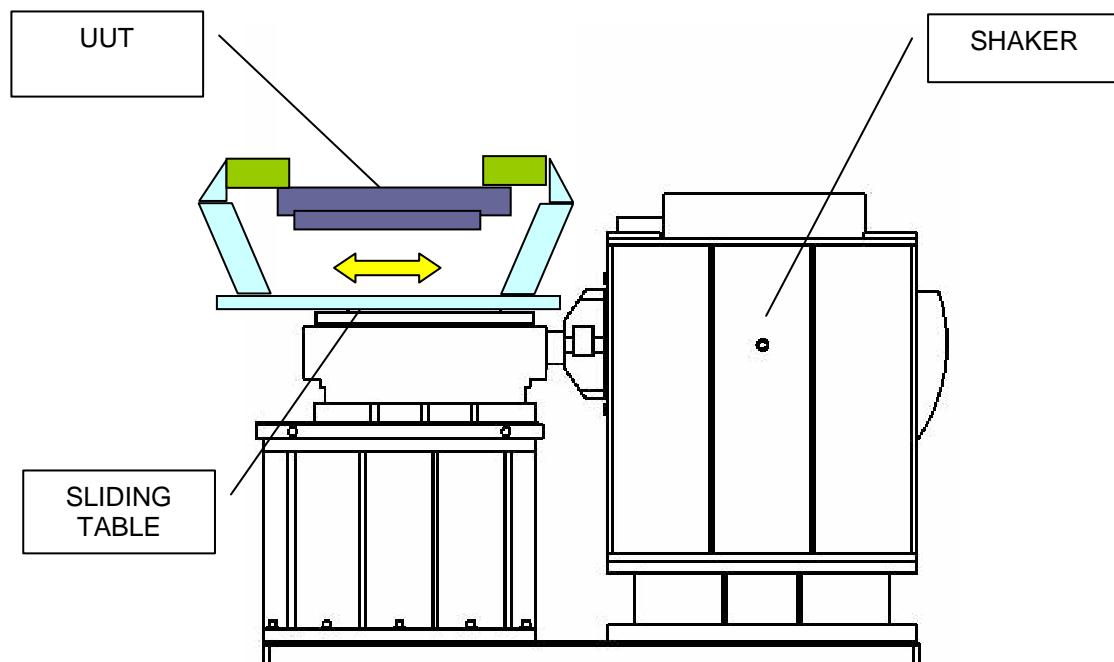


Figure 3-2: U-TOF X-Y VIBRATION TEST SETUP



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4. U-TOF AND FIXTURE FEM DESCRIPTION

To perform the analyses of this document the FEM model of RD1 has been used incrementing its mass from 119.2 kg to 124.4 kg to simulalte the presence of Poron material that was not foreseen in RD1.

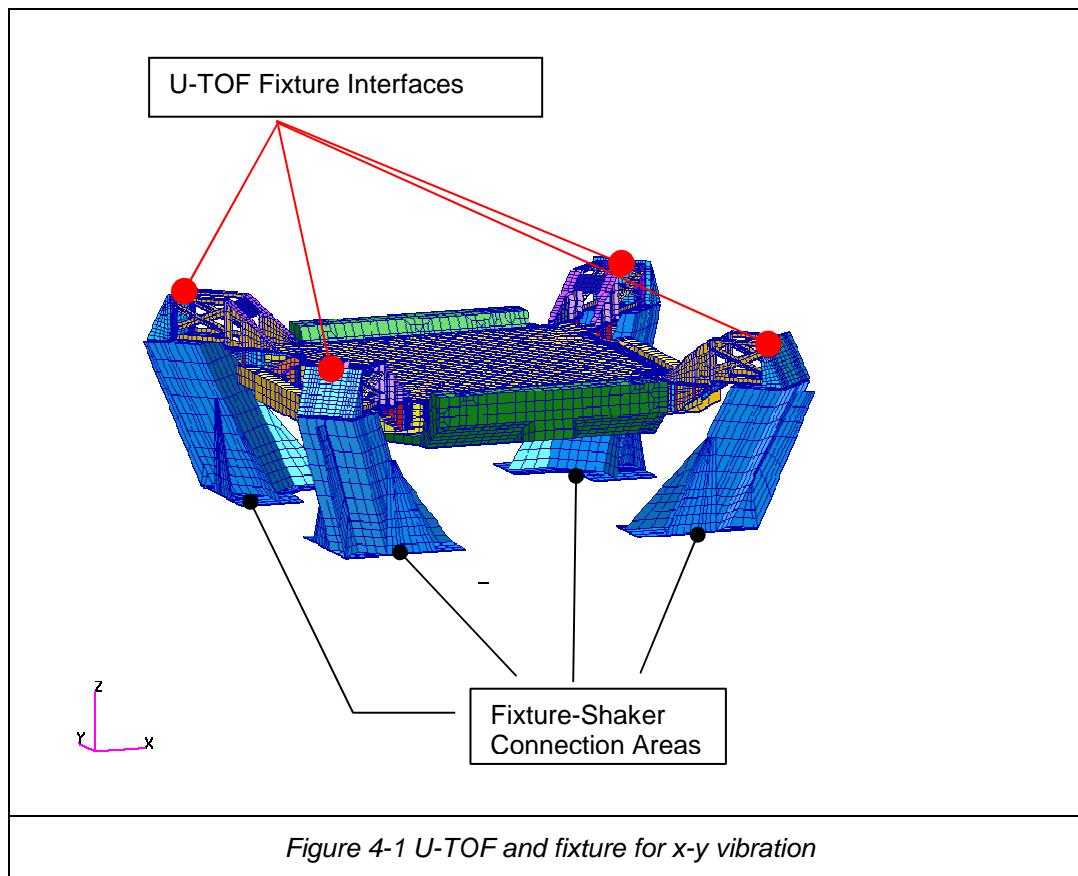
This change results in the following frequencies for the hardmounted configuration :

U-TOF RD1 model Frequency [Hz]	U-TOF updated model Frequency [Hz]	Delta
44.91	43.95	2.2 %
113.80	112.39	1.25 %
120.30	118.64	1.40 %
121.44	119.44	1.67 %

Table 4-1 U-TOF hard mounted frequencies before and after addition of poron mass

The used fixture FEM model is the one described in RD 3, with the required modifications on the U-TOF interface as described in RD 4.

In the following images the two models and a closeout of the interface between U-TOF and FIXTURE is showed





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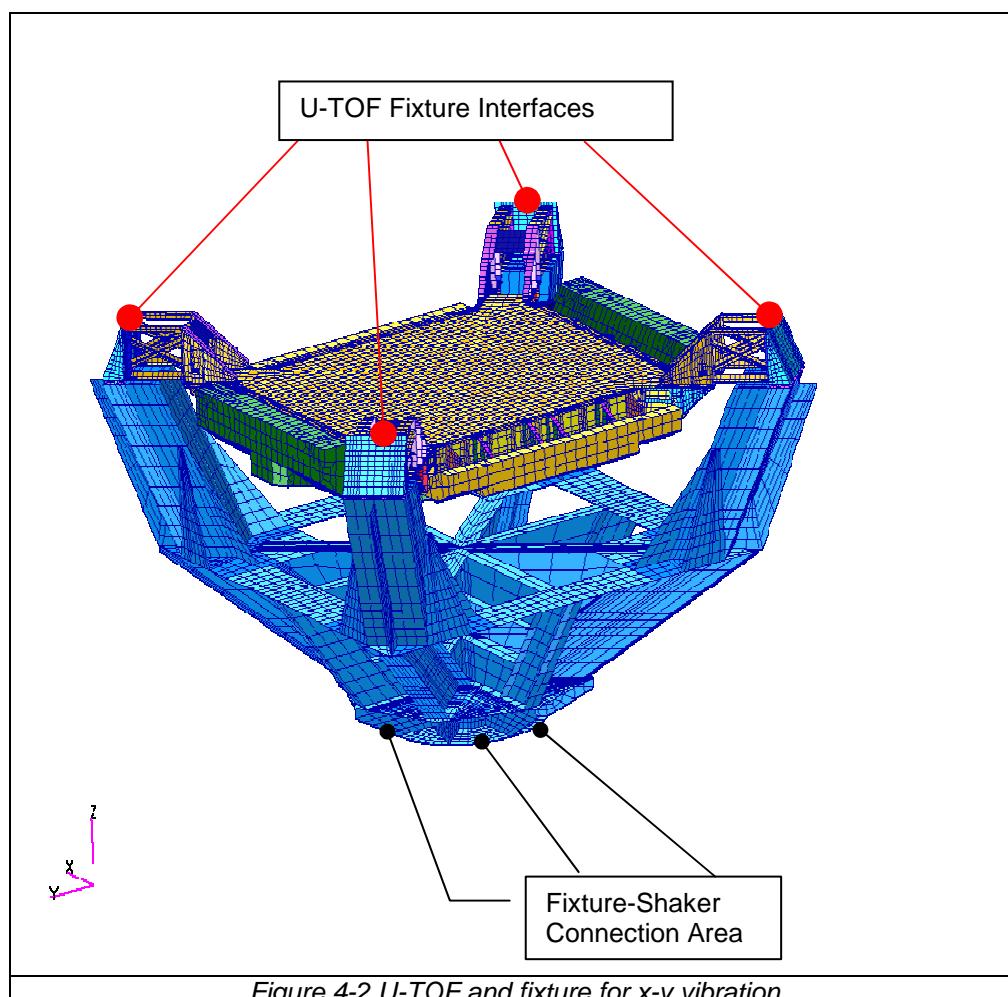


Figure 4-2 U-TOF and fixture for x-y vibration

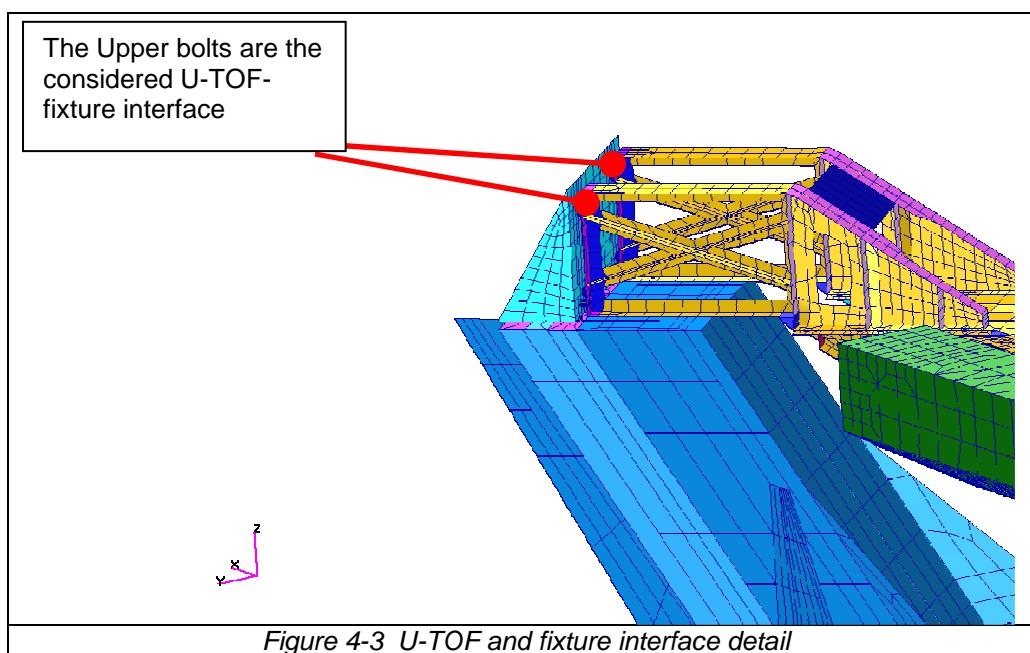


Figure 4-3 U-TOF and fixture interface detail

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5. MODAL ANALYSIS (HARDMOUNTED VS SOFT MOUNTED MODES)

5.1 XY FIXTURE

Main modes of U-TOF hardmounted are compared to the ones obtained with the U-TOF mounted on fixture

U-TOF HARD-MOUNTED MODAL ANALYSIS					U-TOF MOUNTED ON XY FIXTURE				
MODE	FREQ [Hz]	EFF. MASS [Kg] NX	EFF. MASS [Kg] NY	EFF. MASS [Kg] NZ	MODE	FREQ [Hz]	EFF. MASS [Kg] NX	EFF. MASS [Kg] NY	EFF. MASS [Kg] NZ
1	42.13	0.02	0.27	2.88	1	34.83	0.00	0.00	104.38
2	43.95	0.01	0.01	87.28	13	57.30	1.29	0.12	0.00
3	47.16	0.20	0.02	1.67	32	67.58	1.94	0.01	0.02
4	47.82	2.08	0.00	0.68	39	71.06	2.42	0.29	0.00
7	53.51	0.00	0.03	1.40	53	76.82	2.76	0.00	0.00
47	71.28	1.29	0.00	0.04	55	78.20	9.97	0.00	0.16
58	78.89	3.14	0.01	0.82	56	79.43	2.13	0.04	0.50
59	79.54	5.33	0.02	0.20	63	85.66	1.69	0.04	0.00
64	82.01	2.05	0.01	0.00	66	86.51	0.07	1.51	0.02
69	83.68	1.50	0.10	0.00	67	87.23	2.15	0.58	0.01
72	85.05	1.63	0.05	0.02	79	92.94	0.39	23.43	0.01
88	96.28	1.29	0.55	0.04	81	94.82	0.61	1.97	0.00
93	97.74	0.56	2.24	0.00	82	95.23	7.18	0.11	0.03
98	99.88	0.09	1.75	0.03	83	95.48	0.32	1.53	0.00
108	103.57	6.52	0.22	0.02	86	96.84	18.98	0.08	0.05
110	104.27	8.92	0.02	0.02	90	100.04	0.26	5.99	0.24
112	105.04	2.50	0.55	0.10	91	100.70	44.16	0.02	0.01
118	106.20	1.62	0.04	0.02	92	103.44	0.49	1.91	0.12
119	106.75	1.92	0.01	0.11	94	103.99	0.02	2.40	0.07
131	108.66	0.07	1.38	0.08	96	104.48	0.00	10.10	0.21
132	108.93	0.00	1.42	0.02	101	106.33	0.26	8.58	0.00
142	112.39	12.21	0.04	0.01	102	106.52	0.12	16.88	0.25
145	113.55	2.59	0.12	0.05	103	107.24	0.00	6.76	0.34
148	116.09	0.16	3.96	0.35	112	110.21	0.05	10.99	0.02
149	116.44	0.15	4.09	0.00	113	110.51	0.15	3.93	0.01
151	116.79	0.05	3.48	0.00	115	111.04	0.39	3.29	0.09
152	117.34	0.76	4.27	0.03	167	131.70	2.40	0.23	0.02
153	117.77	0.35	1.42	0.02					
154	118.64	1.03	19.81	0.02					
156	119.15	0.70	2.95	0.07					
157	119.44	0.47	14.63	0.34					
163	121.18	0.41	3.63	0.00					
173	125.10	0.00	1.33	0.09					
201	135.00	1.99	1.75	0.01					
201	135.00	1.99	1.75	0.01					
219	141.92	0.33	5.20	0.04					
283	165.49	1.84	0.01	0.03					

Table 5-1: XY FIXTURE VS HARDMOUNTED EIGENFREQUENCIES AND EFFMASS



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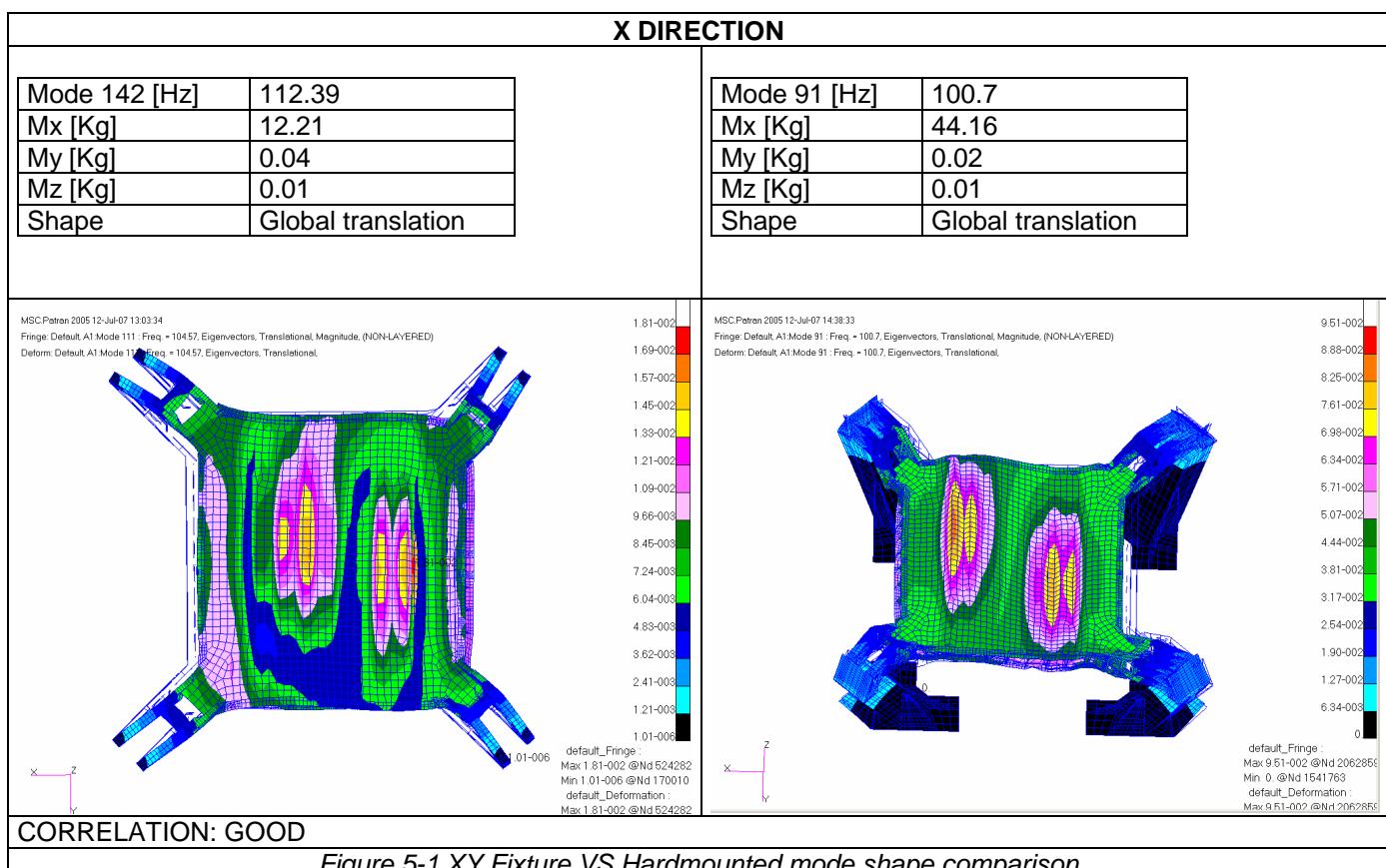
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Figure 5-1 XY Fixture VS Hardmounted mode shape comparison



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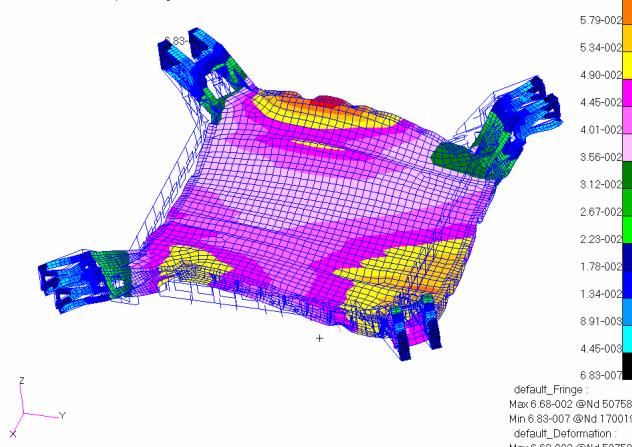
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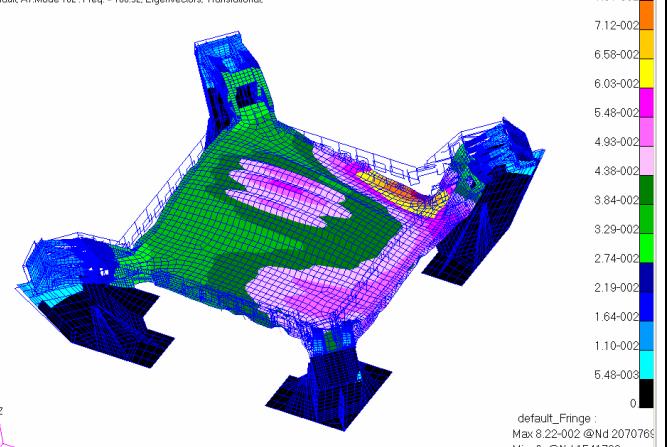
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My [Kg]	19.81
Mz [Kg]	0.02
Shape	Global translation

Mode 101/102 [Hz]	103.33-106.52
Mx [Kg]	0.26/0.12
My [Kg]	8.58/16.88
Mz [Kg]	0/0.25
Shape	Global translation

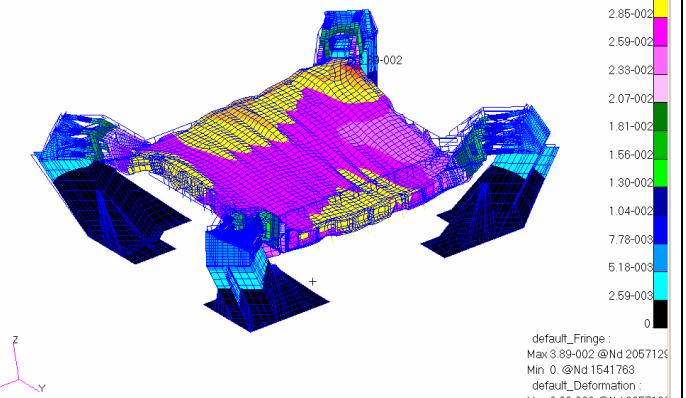
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CORRELATION: GOOD

Figure 5-2 XY Fixture VS Hardmounted mode shape comparison



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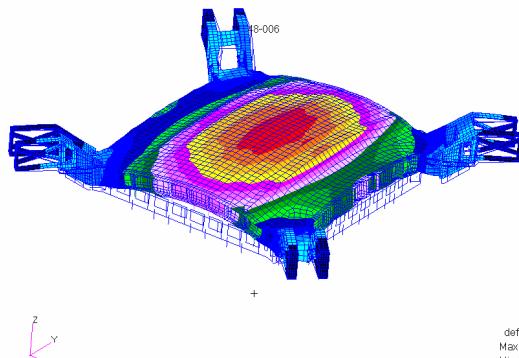
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Z DIRECTION

Mode 2 [Hz]	43.95
Mx [Kg]	0.01
My [Kg]	0.01
Mz [Kg]	87.28
Shape	Global translation

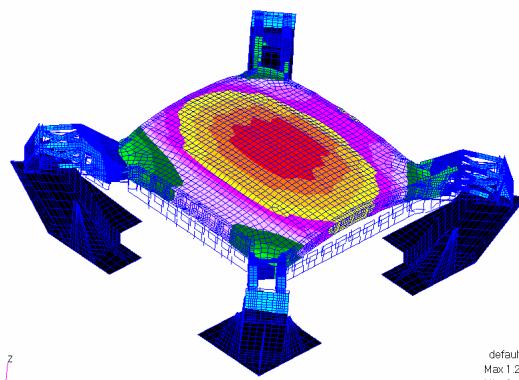
Mode 1 [Hz]	34.83
Mx [Kg]	0
My [Kg]	0
Mz [Kg]	104.38
Shape	Global translation

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default_Deformation :
Max 1.36-001 @Nd 513955

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Max 1.25-001 @Nd 2073084
Frame 2

CORRELATION: GOOD

Figure 5-3 XY Fixture VS Hardmounted mode shape comparison



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5.2 Z FIXTURE

Main modes of U-TOF hardmounted are compared to the ones obtained with the U-TOF mounted on fixture

U-TOF HARD-MOUNTED MODAL ANALYSIS					U-TOF MOUNTED ON Z FIXTURE				
MODE	FREQ [Hz]	EFF. MASS [Kg] NX	EFF. MASS [Kg] NY	EFF. MASS [Kg] NZ	MODE	FREQ [Hz]	EFF. MASS [Kg] NX	EFF. MASS [Kg] NY	EFF. MASS [Kg] NZ
1	42.13	0.02	0.27	2.88	2	35.17	0.08	0.01	101.57
2	43.95	0.01	0.01	87.28	3	38.91	130.40	0.11	0.24
3	47.16	0.20	0.02	1.67	4	40.83	0.67	180.96	0.04
4	47.82	2.08	0.00	0.68	5	42.60	3.81	21.93	0.04
7	53.51	0.00	0.03	1.40	6	47.61	42.63	2.37	0.05
47	71.28	1.29	0.00	0.04	7	48.43	84.03	0.70	0.01
58	78.89	3.14	0.01	0.82	9	54.49	0.24	5.42	0.12
59	79.54	5.33	0.02	0.20	10	54.77	0.01	3.07	0.29
64	82.01	2.05	0.01	0.00	13	55.85	0.09	11.09	0.02
69	83.68	1.50	0.10	0.00	15	56.47	0.23	1.59	0.16
72	85.05	1.63	0.05	0.02	16	57.17	0.10	7.41	0.02
88	96.28	1.29	0.55	0.04	17	57.68	0.09	17.74	0.02
93	97.74	0.56	2.24	0.00	19	59.22	0.00	2.05	0.00
98	99.88	0.09	1.75	0.03	20	59.79	0.01	9.54	0.00
108	103.57	6.52	0.22	0.02	25	61.97	0.84	1.90	0.04
110	104.27	8.92	0.02	0.02	26	62.28	1.32	0.86	0.16
112	105.04	2.50	0.55	0.10	29	62.98	1.64	0.70	0.03
118	106.20	1.62	0.04	0.02	30	63.13	0.70	1.36	0.05
119	106.75	1.92	0.01	0.11	39	68.15	1.43	0.08	0.03
131	108.66	0.07	1.38	0.08	62	79.22	0.09	0.00	1.39
132	108.93	0.00	1.42	0.02	65	81.85	1.34	0.00	0.01
142	112.39	12.21	0.04	0.01	233	156.89	0.00	0.00	3.70
145	113.55	2.59	0.12	0.05	241	160.79	0.00	0.00	7.33
148	116.09	0.16	3.96	0.35	243	161.12	0.00	0.00	29.87
149	116.44	0.15	4.09	0.00	244	161.47	0.00	0.00	185.37
151	116.79	0.05	3.48	0.00	245	161.54	0.00	0.00	2.11
152	117.34	0.76	4.27	0.03	247	163.09	0.02	0.02	10.87
153	117.77	0.35	1.42	0.02	265	169.80	0.00	0.00	3.04
154	118.64	1.03	19.81	0.02					
156	119.15	0.70	2.95	0.07					
157	119.44	0.47	14.63	0.34					
163	121.18	0.41	3.63	0.00					
173	125.10	0.00	1.33	0.09					
201	135.00	1.99	1.75	0.01					
201	135.00	1.99	1.75	0.01					
219	141.92	0.33	5.20	0.04					
283	165.49	1.84	0.01	0.03					

Table 5-2 Z Fixture Vs Hardmounted eigenfrequencies and effective masses



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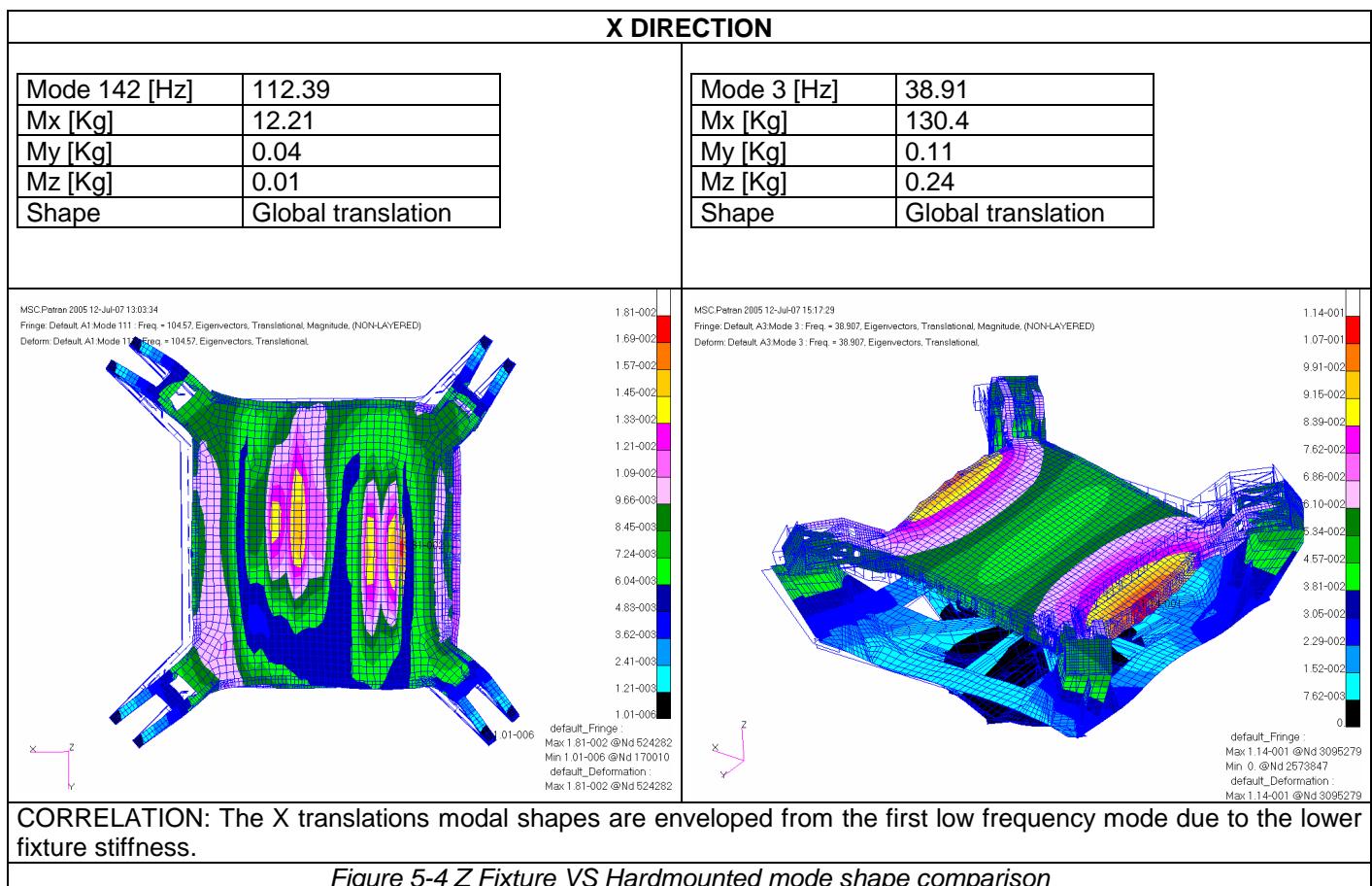
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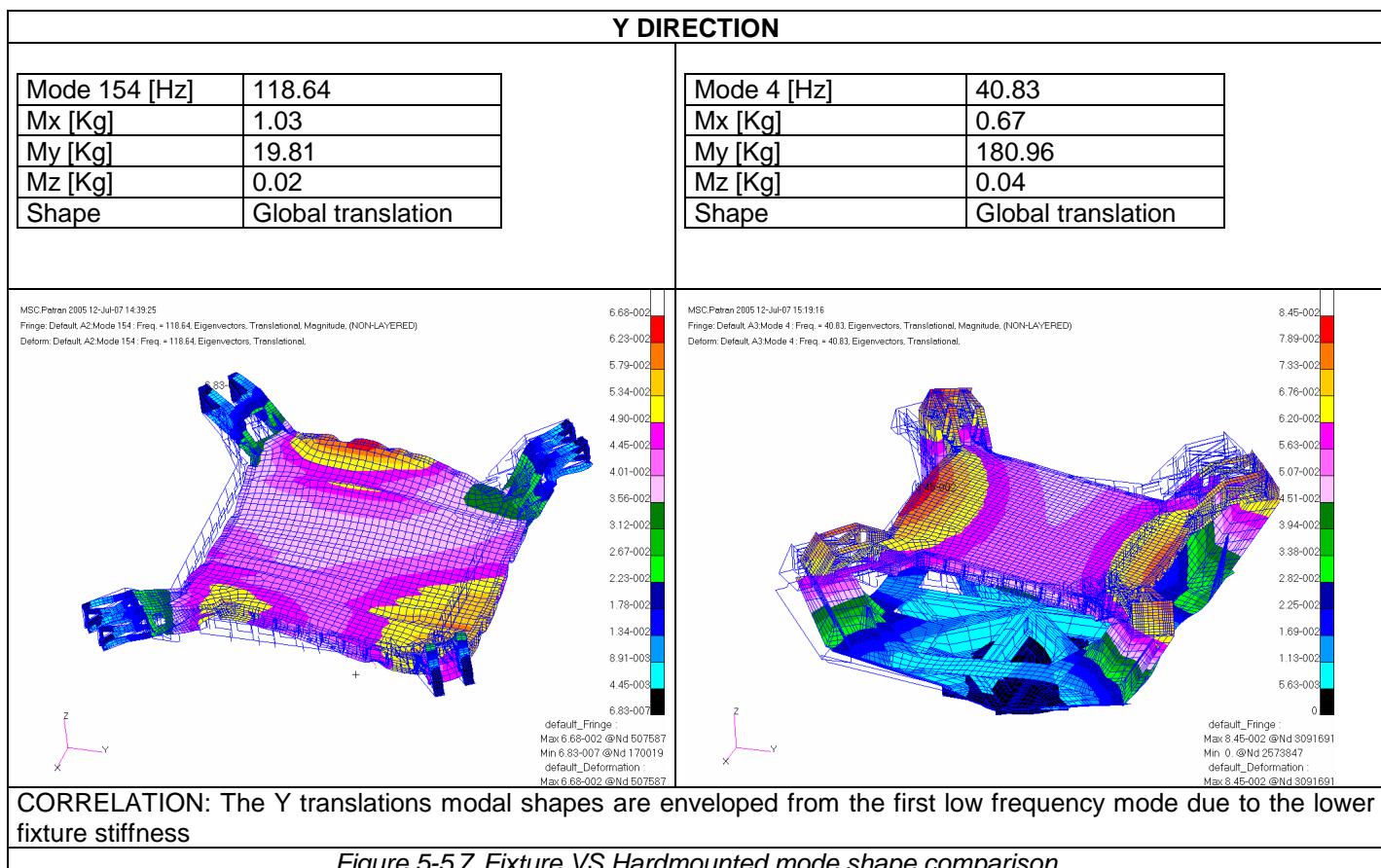
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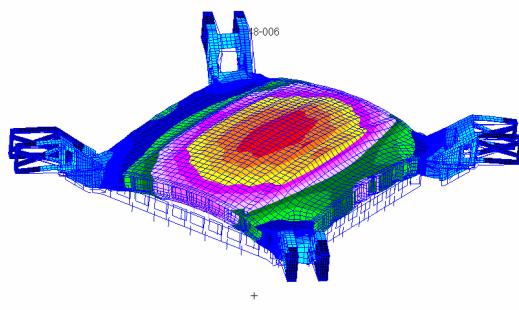
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Z DIRECTION

Mode 2 [Hz]	43.95
Mx [Kg]	0.01
My [Kg]	0.01
Mz [Kg]	87.28
Shape	Global translation

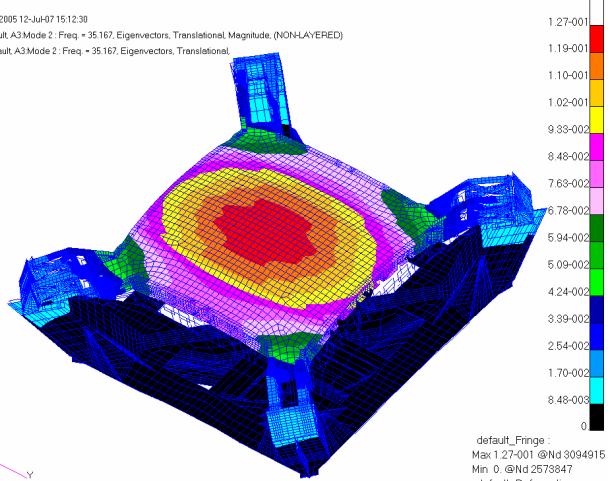
Mode 2 [Hz]	35.11
Mx [Kg]	0.07
My [Kg]	0.01
Mz [Kg]	101.57
Shape	Global translation

MSC.Patran 2005 12-Jul-07 12:33:22
Fringe: Default A1:Mode 2 : Freq = 44.912, Eigenvectors, Translational, Magnitude, (NON-LAYERED)
Deform: Default A1:Mode 2 : Freq = 44.912, Eigenvectors, Translational,



default_Fringe
Max 1.36-001 @Nd 513355
Min 9.08-006 @Nd 170011
default_Deformation:
Max 1.36-001 @Nd 513355

MSC.Patran 2005 12-Jul-07 15:12:30
Fringe: Default A3:Mode 2 : Freq = 35.167, Eigenvectors, Translational, Magnitude, (NON-LAYERED)
Deform: Default A3:Mode 2 : Freq = 35.167, Eigenvectors, Translational,



default_Fringe
Max 1.27-001 @Nd 3094915
Min 0. @Nd 2573847
default_Deformation:
Max 1.27-001 @Nd 3094915

CORRELATION: GOOD

Figure 5-6 Z Fixture VS Hardmounted mode shape comparison



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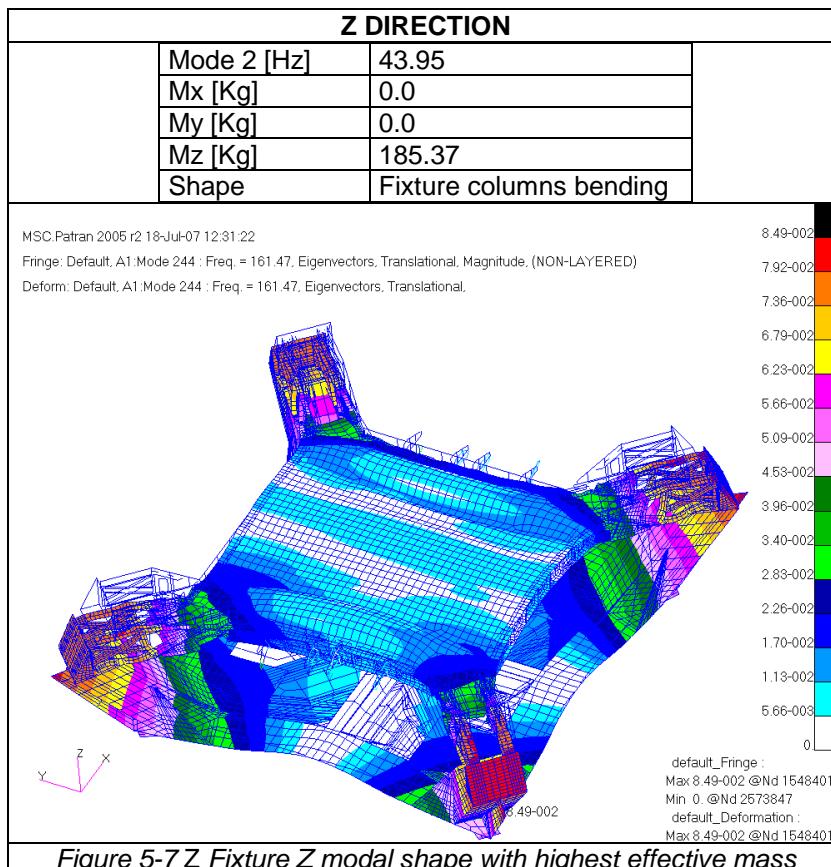
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For Information the modal shape in the following table the modal shape in z direction with the highest effective mass is shown. This is only a fixture mode that not influence the U-TOF CoG behaviour (Figure 6-15),



5.3 COMMENTS

The modal correlation is good for the XY fixture considering all the output directions for frequency, mode shape and effective mass.

For what concerns the Z fixture the Z direction correlation is good for frequency, mode shape and effective mass, while the X and Y directions provide poor correlation for frequency and effective mass, while the mode shape is well matched.



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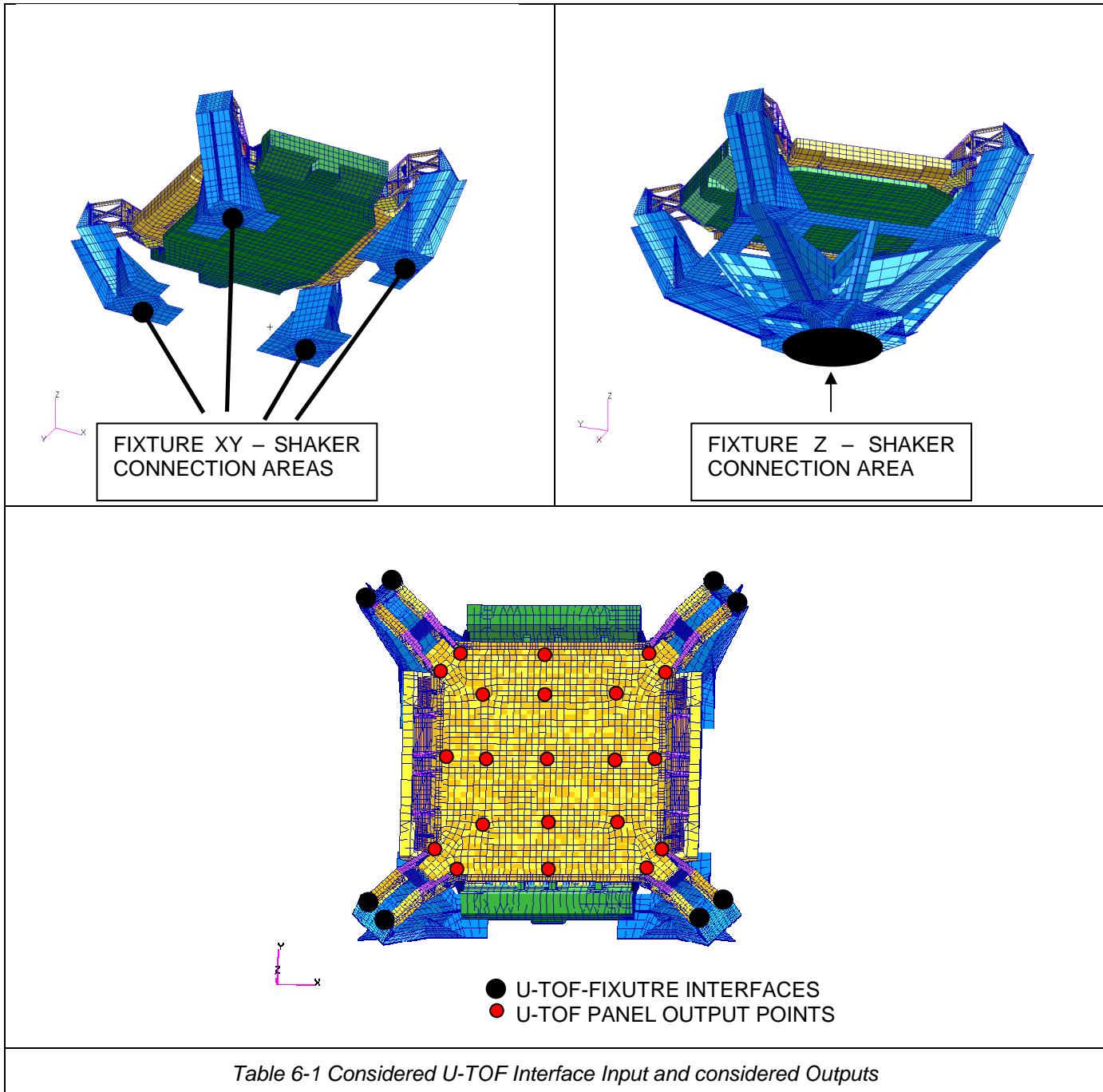
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6. RANDOM RESPONSE ANALYSIS

The following table show the U-TOF applied interfaces input estimated at the control points of the interface between U-TOF and fixture.



Frequency [Hz]	PSD [g^2/Hz]
20	0.009
45	0.009
125	0.025
300	0.025
900	0.001
2000	0.001
<hr/>	
Overall grms 3.2	

Table 6-2 Considered U-TOF Interface Input

The considered interfaces are the highest bolt nodes since during the vibration test the control accelerometers will be placed near that bolts on the fixture top.

In order to guarantee this interface input the necessary Fixture input was calculated.

The used modal base is up to 500 Hz and the structural damping is set to 5%.

6.1 U-TOF INTERFACE RESPONSE X-Y-Z INPUT

The following figures show the X, Y and Z inputs compared to the UTOF interfaces output.

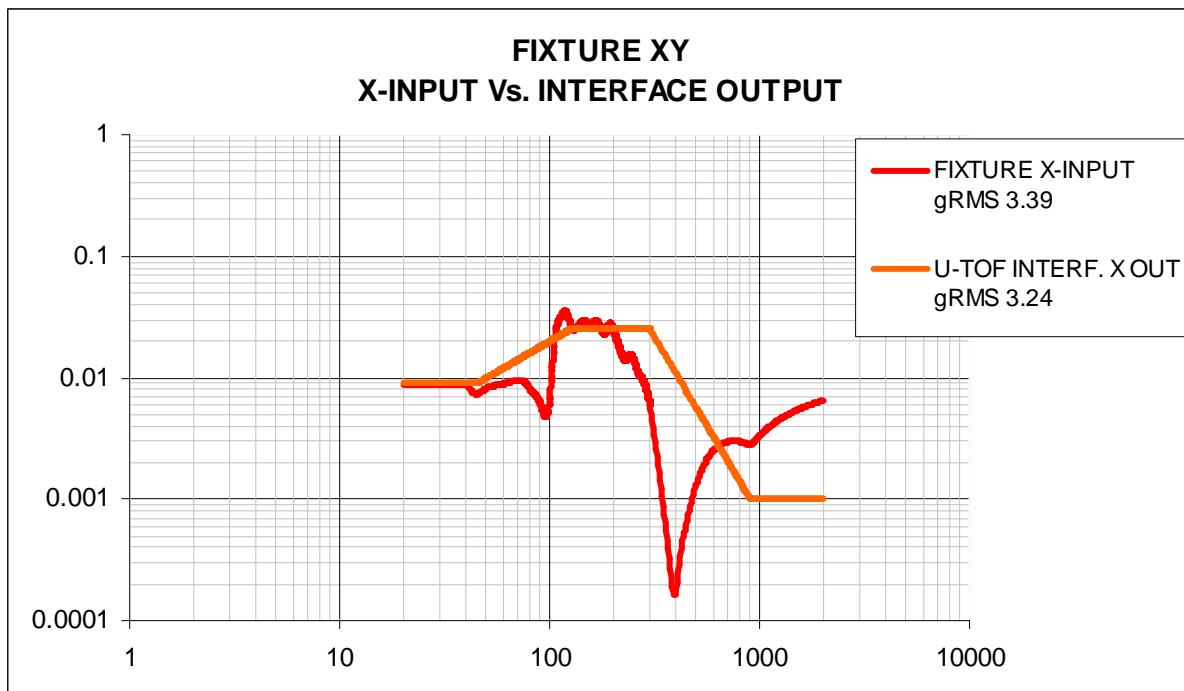


Figure 6-1 Fixture XY X-input Vs. U-TOF interfaces X Output



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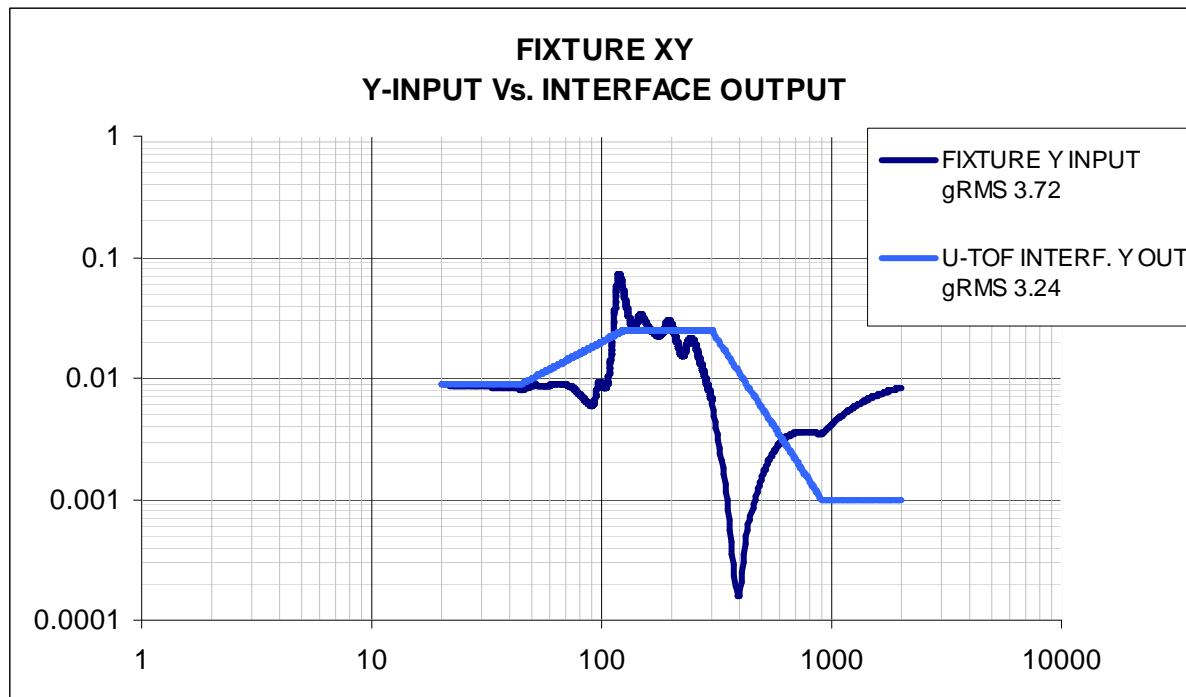
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Figure 6-2 Fixture XY Y-input Vs. U-TOF interfaces Y Output

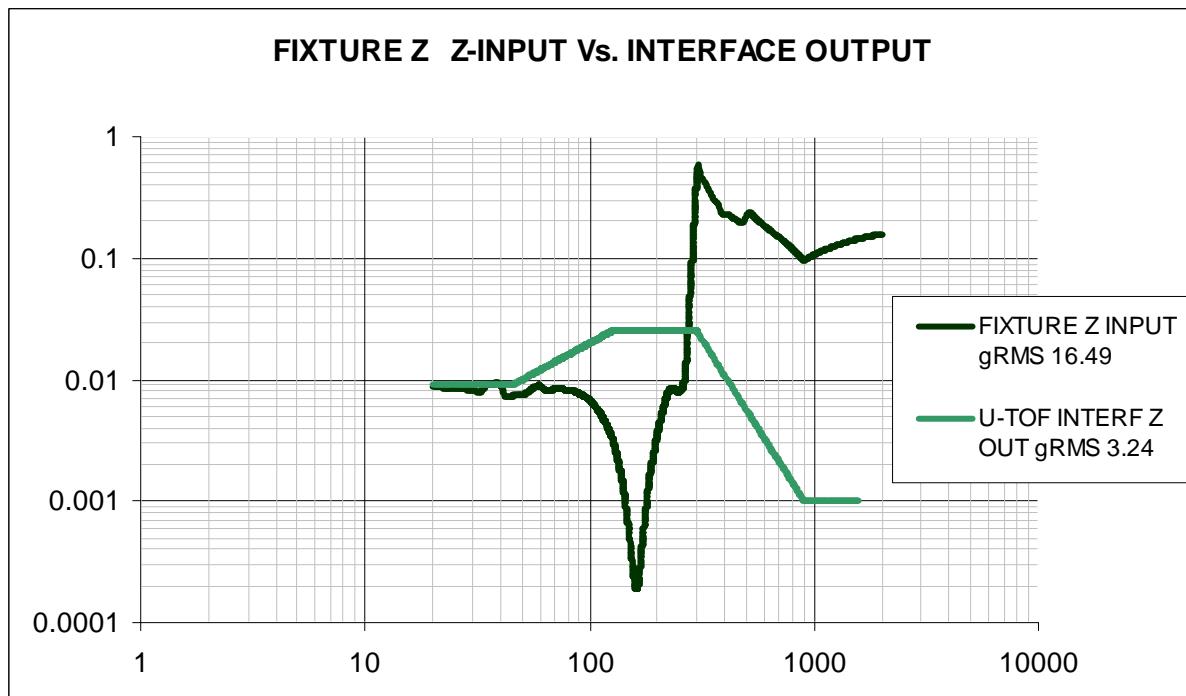


Figure 6-3 Fixture Z Z-input Vs. U-TOF interfaces Z Output

The gRMS values for X and Y directions are similar to the Table 6-2 values, while the Z-Input value is very high; this is due to the high frequency contribute.

Using this updated value the random analysis was performed.

For information the different response between upper and lower bolts on the U-TOF interface is showed in the next graph:

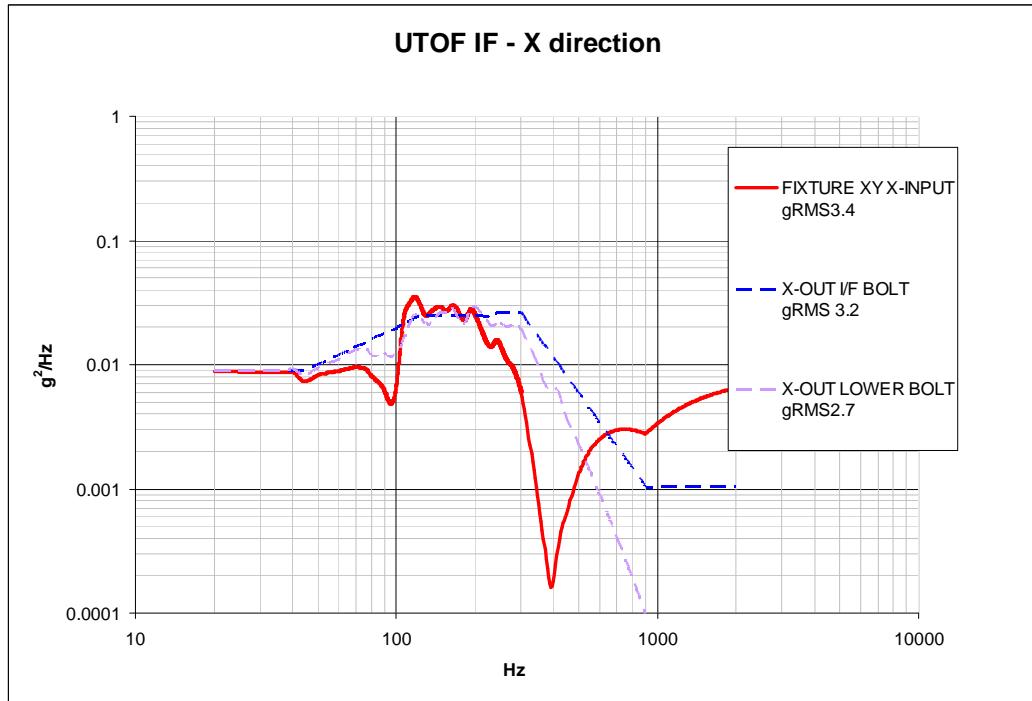


Figure 6-4 X-INPUT comparison with the I/F bolts output and the lower connection bolts output.

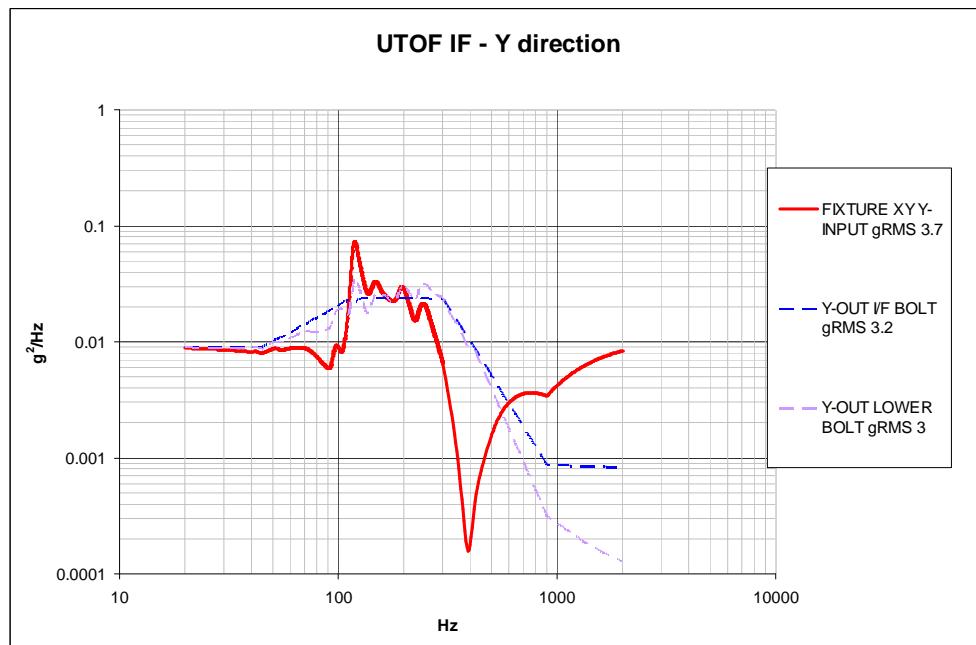


Figure 6-5 Y-INPUT comparison with the I/F bolts output and the lower connection bolts output.

The interface bolt outputs is equal to the Table 6-2 values, while the other connection bolts output shape is slightly lower. The gRMS values are similar

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The U-TOF-Fixture Z connection bolts are analyzed and the following figure show the obtained results.

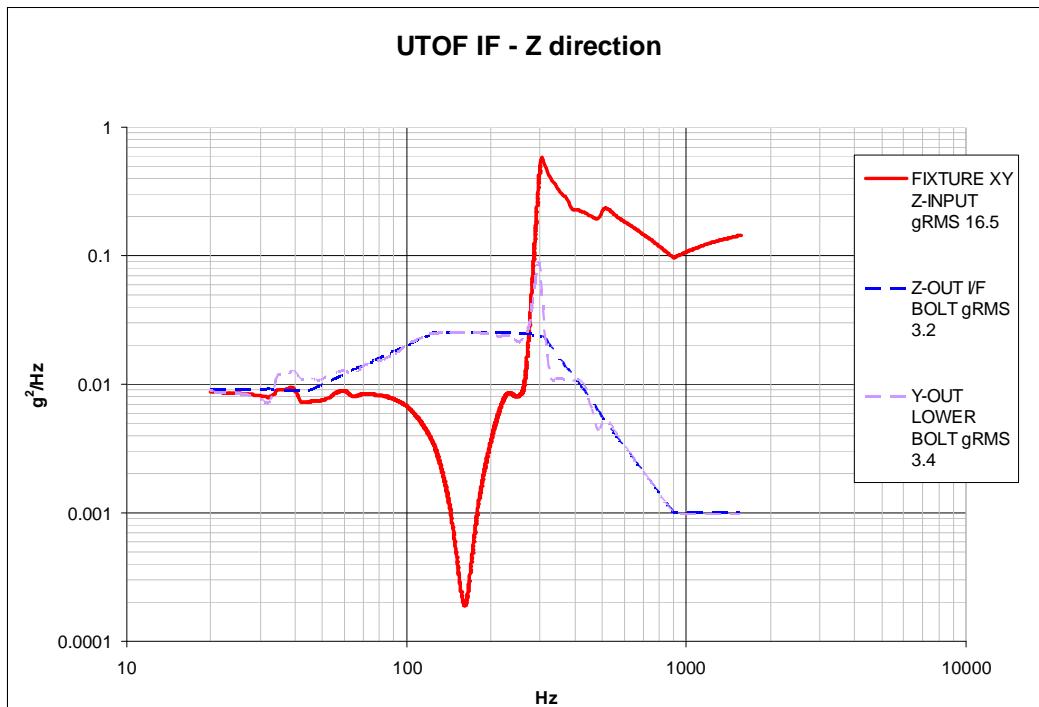


Figure 6-6 Z-INPUT comparison with the I/F bolts output and the lower connection bolts output.

The interface bolt outputs is equal to the Table 6-2 values, while the other connection bolts output shape is slightly lower. The gRMS values are similar

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6.2 U-TOF RESPONSE ON STRUCTURE

The obtained results are the for the nodes on panel are shown in the following figure.

For the X-Input the obtained results are:

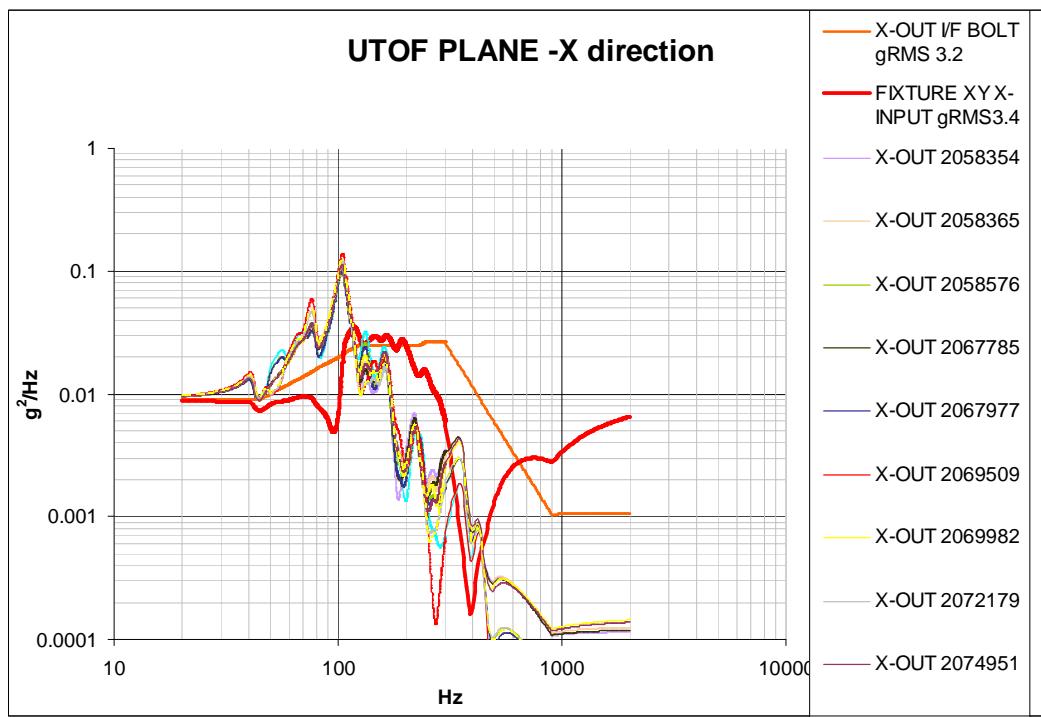


Figure 6-7 U-TOF panel X-Output

Their behaviours are similar therefore the central node was considered the most representative and the out of axes outputs are considered.

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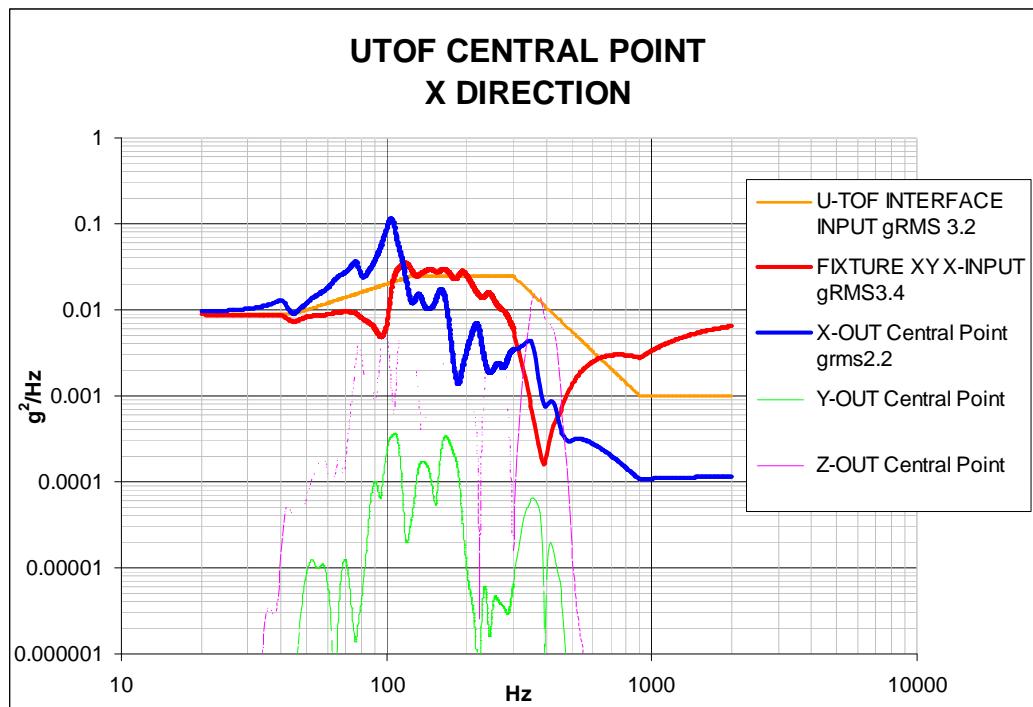


Figure 6-8 U-TOF central point X-INPUT response

The central point output was compared with the CoG response found by the interfaces force analysis (paragraph 6.3).

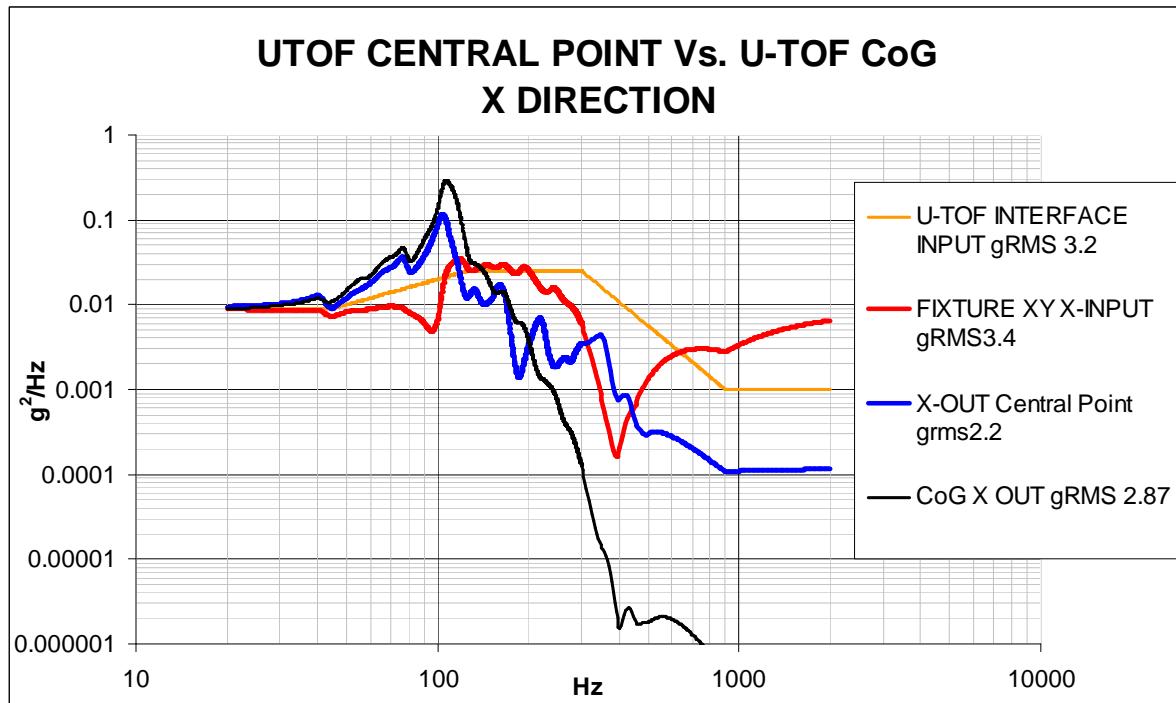


Figure 6-9 U-TOF central point Vs. U-TOF CoG

For the Y-Input the obtained results are:

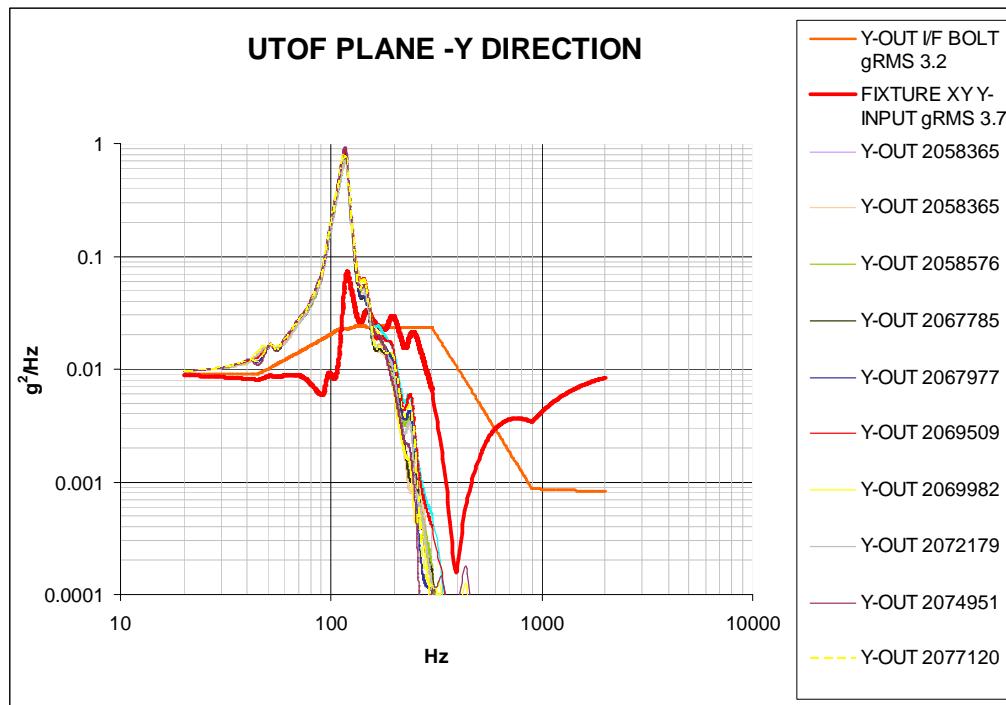


Figure 6-10 U-TOF panel Y-Output

Their behaviours are similar therefore the central node was considered the most representative and the out of axes outputs are considered.

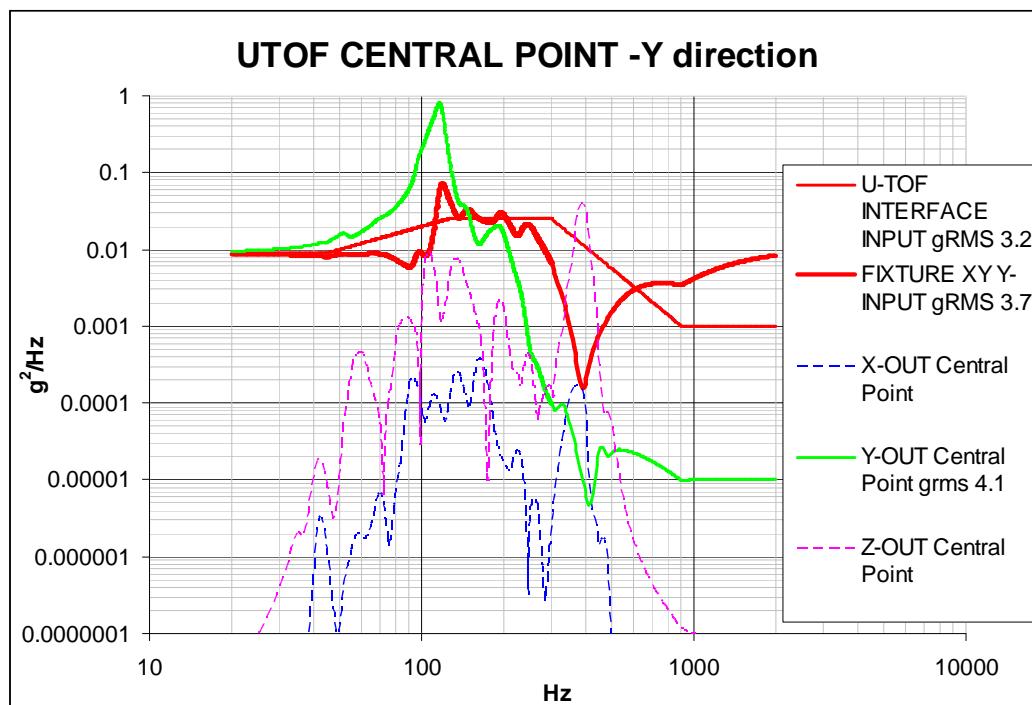
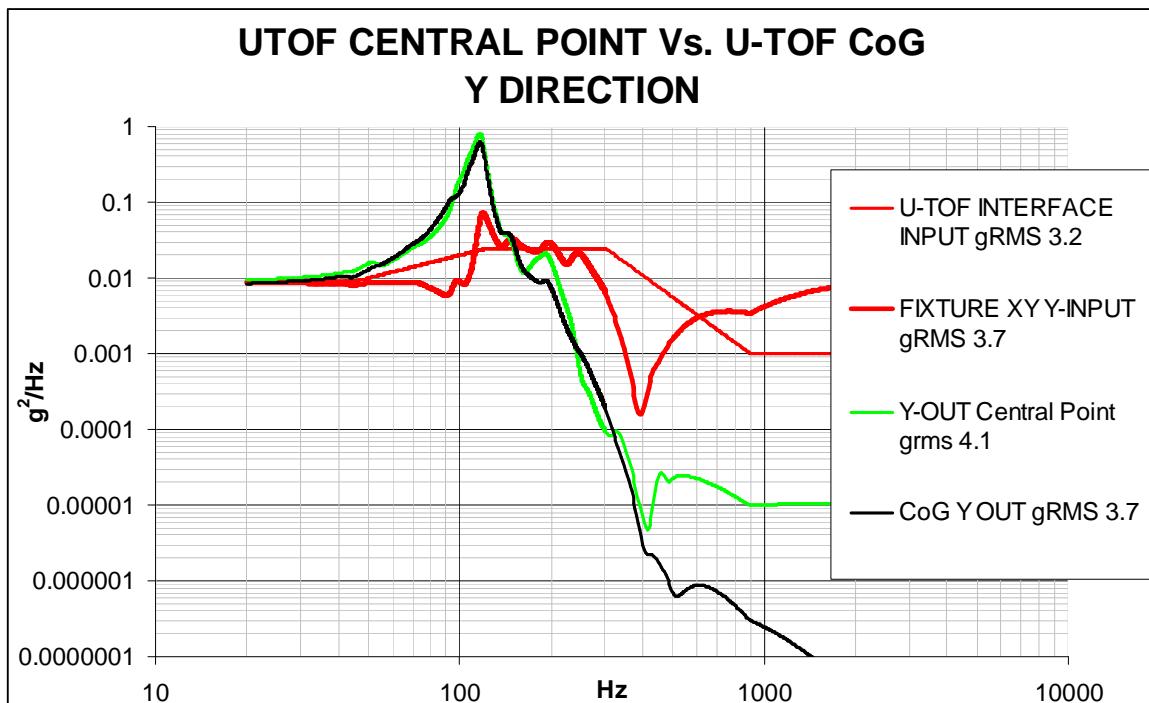


Figure 6-11 U-TOF central point Y-INPUT response

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The central point output was compared with the CoG response found by the interfaces force analysis (paragraph 6.3).



For the Z-Input the obtained results are:

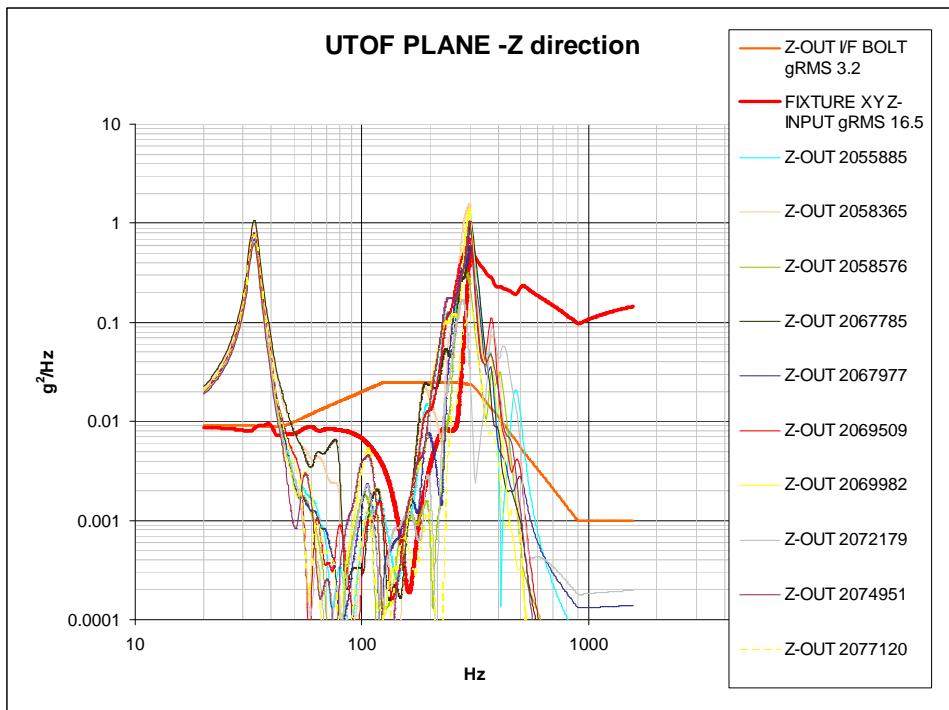


Figure 6-13 U-TOF panel Z-Output

Their behaviours are similar therefore the central node was considered the most representative and the out of axes outputs are considered.

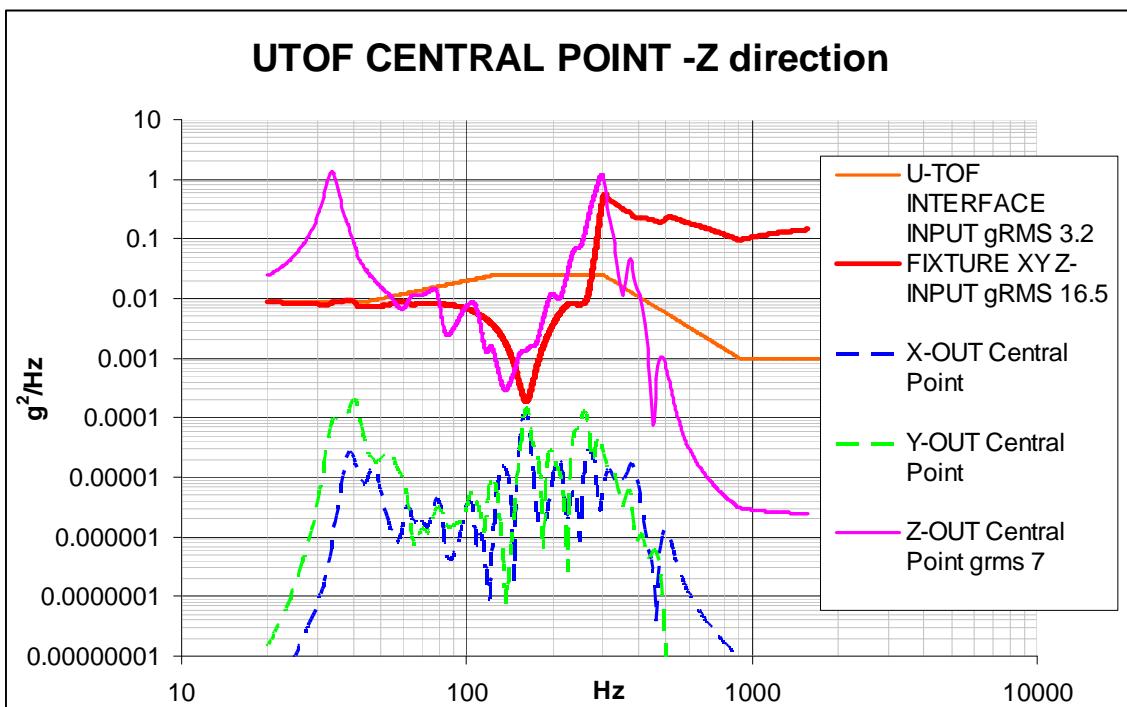


Figure 6-14 U-TOF central point Z-INPUT response



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The central point output was compared with the CoG response found by the interfaces force analysis (paragraph 6.3).

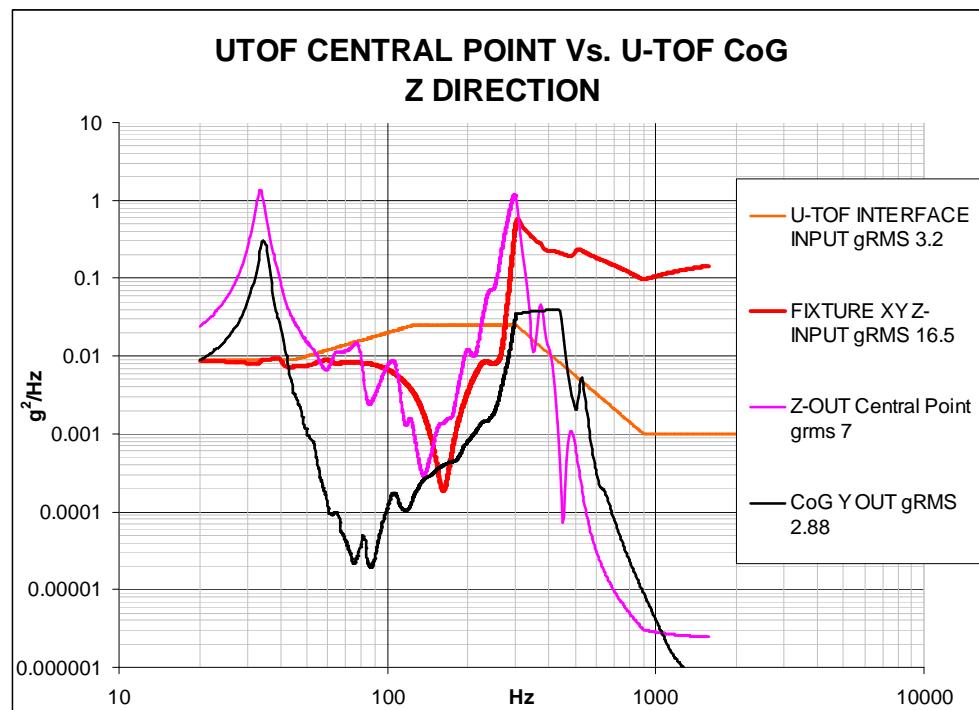


Figure 6-15 U-TOF central point Vs. U-TOF CoG



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6.3 IF FORCES RESPONSE AND BOLT VERIFICATION

RMS Response of U-TOF mounted on fixture interface bolts forces were calculated. In particular the U-TOF is jointed to the fixture by 8 bolts and 4 shear pins for each bracket.

The following figure shows a detail of the connection points and the bracket numeration.

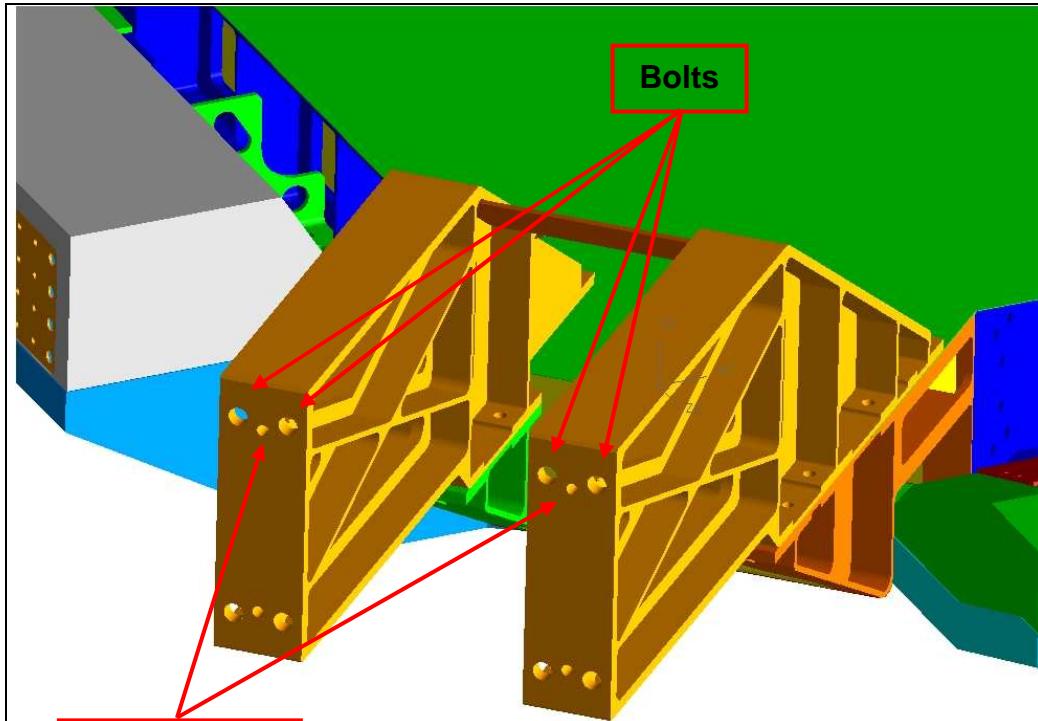


Figure 6-16: Interface joints

FIGURA CON numerazione racket

Figure 6-20: Force response points on U-TOF interface bolts

The rms forces found by random analysis on each axial bolt and shear pin are shown.

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	Bracket 1	Bracket 2	Bracket 3	Bracket 4
	Axial Force [N] RMS 1sigma	Axial Force [N] RMS 1sigma	Axial Force [N] RMS 1sigma	Axial Force [N] RMS 1sigma
X-INPUT	85.54	110.85	189.33	108.89
	119.68	140.68	91.23	145.38
	338.74	187.57	327.65	187.96
	187.37	392.01	568.78	371.31
	121.74	115.37	138.32	113.60
	114.19	96.14	110.66	98.59
	400.84	178.54	369.44	193.45
	197.67	332.07	514.83	327.07
Y-INPUT	196.79	115.95	181.19	121.15
	94.08	150.49	96.53	148.92
	307.45	509.63	315.98	512.96
	562.11	363.85	545.44	351.49
	162.65	99.77	134.40	96.82
	109.48	183.15	112.52	197.38
	353.45	546.52	354.63	564.27
	519.93	313.53	492.07	313.53
Z-INPUT	248.09	484.91	252.12	520.32
	318.63	487.75	324.81	524.93
	234.85	245.84	234.07	256.43
	204.93	329.62	196.49	347.76
	457.93	350.71	434.68	377.49
	453.52	288.71	444.79	316.47
	310.39	228.67	306.46	239.95
	222.69	255.35	203.56	275.96

Table 6-3 Axial bolt force values

	Bracket 1 shear force [N] RMS 1sigma	Bracket 2 shear force [N] RMS 1sigma	Bracket 3 shear force [N] RMS 1sigma	Bracket 4 shear force [N] RMS 1sigma				
	Vertical	In-Plane	Vertical	In-Plane	Vertical	In-Plane	Vertical	In-Plane
X-INPUT	31.29	24.62	44.93	24.13	38.16	26.29	37.47	25.60
	50.52	14.13	93.59	23.45	45.52	38.26	102.22	21.58
	45.52	24.33	30.02	24.53	46.11	58.96	28.55	25.70
	83.68	22.96	53.66	14.13	78.87	11.28	58.57	13.24
Y-INPUT	32.37	28.15	47.09	31.88	37.87	27.08	41.89	28.55
	35.41	22.76	78.58	11.28	37.87	27.08	84.95	11.97
	46.21	31.00	31.88	29.33	45.52	29.23	39.04	25.90
	70.04	12.07	37.28	21.19	82.21	11.58	54.15	22.96
Z-INPUT	76.42	22.96	73.97	24.03	59.74	19.72	74.56	21.29
	288.51	22.46	396.42	49.74	322.95	21.78	480.40	47.58
	76.52	25.70	76.62	20.50	62.88	23.05	67.69	18.34
	382.98	48.27	309.70	21.78	418.30	49.05	366.89	22.96

Table 6-4 Shear Pin force rms values

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In order to verify the joint during the vibration test the following maximum 3 sigma values were considered adding also to the shear vertical force the UTOF weight:

$$\text{Axial force} = 568.78 \times 3 = 1710 \text{ N}$$

$$\text{Shear Force} = \sqrt{F_{in_plane_MAX}^2 + (F_{vertical_MAX} + F_{weight})^2} \times 3 = 1680 \text{ N}$$

Load Cases	Axial Force [N]	Shear Force [N] In-Plane+Vertical
1	1710	0
2	0	1680

Table 6-5 Load cases used to verify respectively the axial bolt and the shear pins

The following tables show the bolt joint data and obtained results:

U-TOF INTERFACE BOLTS	
JOINT DEFINITION	VALUE
Bolt Size	NAS1351-5
Nominal Diameter [mm]	7.938
Thread Pitch [1/h]	24
Bolt Material	A286 (U 200 Ksi)
Bolt Material FTU [MPa]	1379
Bolt Material FTY [MPa]	1241
Bolt Material FSU [MPa]	827
Bolt Material FSY [MPa]	745
Temperature Correction Factor	0.94
Plastic bending factor for circular cross section	1.7
Fitting Factor	1.15
Dry Torque coefficient	0.2
Loading plane factor	0.5
Joint Load Factor (Steel bolt on Al plate)	0.266
Plate Material	AL7075 T7351
Plate thickness [mm]	6
BEARING AND LUG DATA	
BEARING AND LUG DATA	VALUE
Hole diameter [mm]	7.938
e/D	1.45
Distance Hole-end plate (Lug an. Tension)	11.5
Distance Hole-end plate (Lug an. Shear)	11.5
Plate FBRU [MPa]	703
Plate FBRY [MPa]	544
Lug Ftu [MPa]	468
Lug Fty [MPa]	393
Lug Fs [MPa]	262
Lug Fsy [MPa]	219
WORST CASE LOAD DEFINITION	
WORST CASE LOAD DEFINITION	VALUE
LOAD CASE	1
AXIAL LOAD	1710
SHEAR LOAD	0
RESULTS	
RESULTS	VALUE
Max. Torque [Nm]	32.12
Min. Torque [Nm]	28.15
minimum MoS	0.172

Table 6-6 U-TOF bolts

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U-TOF SHEAR PIN	
JOINT DEFINITION	VALUE
Shear Pin Nominal Diameter [mm]	6.35
Shear Pin Material	A286 (U 200 ksi)
Shear Pin Material FSU [MPa]	827
Shear Pin Material FSY [MPa]	745
Fitting Factor	1.15
Yield Safety Factor	1.25
Ultimate Safety Factor	2
Temperature Correction Factor	0.94
Plate Material	AL7075 T7351
Plate thickness [mm]	6
BEARING AND LUG DATA	VALUE
Hole diameter [mm]	7.938
e/D	1.45
Distance Hole-end plate (Lug an. Tension)	11.5
Distance Hole-end plate (Lug an. Shear)	11.5
Plate FBRU [MPa]	703
Plate FBRY [MPa]	544
Lug Ftu [MPa]	468
Lug Fty [MPa]	393
Lug Fsu [MPa]	262
Lug Fsy [MPa]	219
WORST CASE LOAD DEFINITION	VALUE
LOAD CASE	2
AXIAL LOAD	1710
SHEAR FORCE [N]	1680
RESULTS	VALUE
minimum Mos	0.64

Table 6-7 U-TOF shear pin

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7. CONCLUSIONS

7.1 TEST SETUP PERFORMANCES

The proposed test setup reduces the first frequency of the U-TOF according to the following table:

	Hard-Mounted Freq. [Hz]	U-TOF Fixture XY mounted Freq. [Hz]	U-TOF Fixture Z mounted Freq. [Hz]
X DIRECTION F1	112.39	100.7	38.91
Y DIRECTION F1	118.64	106.33/106.52	40.83
Z DIRECTION F1	43.95	34.83	35.17
Frequency reduction due to fixture flexibility			

The modes shape and effective masses are similar therefore the test setup can be considered reliable provided that for the first frequency requirement verification (that is requested in hardmounted condition only analytically feasible) it is taken into account the flexibility of the fixture. In particular the XY fixture installation is representative for the X-Y U-TOF hardmounted behaviour, while the Z fixture installation is representative for the Z U-TOF hardmounted behaviour.

To improve the frequency shift it is required to act on a major modifications of the fixture.

The gRMS values predicted on the structure and at the CoG of the U-TOF are reported in the following table:

	U-TOF panel central point	U-TOF CoG
X DIRECTION	2.2	2.87
Y DIRECTION	4.1	3.7
Z DIRECTION	7	2.88

Table 7-1 U-TOF gRMS values on structure and at CoG

The MoS for the connection bolts and pins are positive and the forces transferred are lower than the ones used in RD1

7.2 CRITICALITIES

From the predictions a good controllability is highlighted in terms of cross talks and input to the base of the fixture with respect to the control points.

A average of max control on 4 points is suggested with close monitoring of the cross talks to confirm the predictions. Selection of max or average strategy is suggested to be defined according to the preliminary low level runs.

7.3 RECOMMENDATION FOR FIXTURE DETAILED DESIGN PHASE

No recommendations, the design of RD 4 is sound from dynamic response point of view.

Care must be taken in the detailed design f the bolted connections(use of self locking helicoils, minimum hole distances for the bolts, tolerances for the pins etc...) and the integration sequence of the U-TOF.